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AUTHOR Schneider, Barbara L.
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ABSTRACT

After clarifying some of the problems in determining the effectiveness of schools, this study attempts to show how the impact of school resources on achievement can be measured. Several mathematical models are examined that provide quantitative information on the relationship between school resources and student achievement. The sample includes 493 elementary school children, grades 3 through 7, in four urban schools. Data on schools and student populations were acquired during visits to the schools and surrounding neighborhoods. Information on individual students was obtained from questionnaires and interviews and verified by school records when possible. Achievement scores were from the Iowa Test of Basic Skills. The unit of observation was the individual student. The overall findings indicate that when the individual student is the unit of analysis, student, peer group, teacher, and school characteristics are related to academic achievement. (Author/JM)

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Further Evidence of School Effects

Barbara L. Schneider

School of Education

Northwestern University

EA 015 587

Running head: Further Evidence of School Effects

Abstract

This study clarifies some of the problems in determining the effectiveness of schools and explains how the impact of school resources on achievement can be measured. Several mathematical models are examined that provide quantitative information on the relationship between school resources and student achievement. The sample includes 493 elementary school children, grades three through seven, in four urban schools. The unit of observation is the individual student. The overall findings indicate that when the individual student is the unit of analysis, student, peer group, teacher, and school characteristics are related to academic achievement.

Further Evidence of School Effects

Introduction

Recent evidence indicates that school resources make a difference in student achievement. The findings of Hanushek (1972), Murnane (1975), Summers and Wolfe (1977), represent a shift from earlier analyses of the Coleman data (1966) that seem to support the claim that school resources have little effect on achievement gains. The basis for this change seems to stem from a deeper understanding of the technical problems in estimating how schools make a difference.

The method for estimating the impact of school resources on achievement has been an input-output model adapted from economic production functions. The educational production function has generally been represented by: (1)

$$Y = f(x_1, x_2, x_3, x_4 \ldots x_n)$$

where

Y = output, usually in terms of academic achievement,

$(x_1 \ldots x_n)$ = inputs, individual student, peer group, teacher and school characteristics, etc.

There are, however, several differences between economic and educational production functions. The purpose of the economic production function is to describe maximum production boundaries, assuming that each of the production components is operating at its most efficient level. At this time, estimating the production possibilities for educational processes would be nearly impossible because: 1) no single model

for the production process exists, due to the limitations of current learning theory and measurement methods, and 2) the assumption that schools are operating at their most efficient level is questionable.

In addition, there are several process distinctions between educational and economic production functions. Educational production functions describe multiple output processes and products. Time is also a critical element in the educational production process; current production is affected by previous learning and may have an effect on future learning. The amount, quality, and ordering of student and teacher time are likely to affect the production learning process. Thus, the expected output is contingent upon preceding and intervening events. Moreover, the student, unlike raw materials, will react and respond to the production process in a manner which may not be controllable. Therefore, unlike the manufacturing process, the decision rules for maximizing profits, minimizing costs or maximizing utility for educational production functions are severely constrained by the multiple output process, time factors, and production materials.

Technical Econometric Problems

In spite of these problems, the production function approach is useful. Its value is that it provides a mechanism for quantitatively analyzing what selected resources affect academic achievement. The method requires identifying a model of production. This distinguishes production functions from process product research (Doyle, 1977) which examines the relationship between selected teacher characteristics and

student learning. Production functions can avoid the strict controls of experimental designs. Moreover, production functions can help to determine equations for simultaneous analyses which have promise for examining the interdependent relationships among student achievement, motivation, and instructional techniques.

The usefulness of the production function can be severely constrained by certain technical problems. The first problem is identifying the model; this involves selecting the output and input variables. The most frequently used output at the elementary school level has been achievement of basic skills as measured by standardized tests. The input variables have generally been represented by several factors including: 1) student, 2) peer group, 3) teacher, and 4) school characteristics. In constructing the model, there should be a set of prior decision rules regarding how many variables will represent each factor.[1]

Previous studies have revealed some repeated relationships of variables to academic achievement. These include: 1) for student characteristics: sex, birth order, combined family income, family size, prior ability level and engaged learning time; 2) for peer group characteristics: peer racial characteristics, peer group academic performance; and 3) for teacher characteristics: verbal facility (Hanushek, 1972; Walberg and Marjoribanks, 1976; Harnischfeger and Wiley, 1977). Conversely, there are variables which have been shown not to be important factors in determining achievement gains, such as number of books in the school library and age of the school building (Averch, 1974). It seems we no

longer have to go on a "fishing expedition" to find variables suspected of influencing achievement. What is needed is a refinement of the measures used in the model. Measurements of how school resources are used rather than specifying presence or absence of a variable would improve the precision of the model.

A second problem with educational production function has been the use of aggregated data such as means. The greatest difficulty with using mean scores as output measures is that the effect of a particular school, classroom, or specific resource is obscured. In relation to school effects, studies that have used individual achievement scores within specific schools and classrooms have found different results from earlier studies in which aggregated mean scores were used.[2]

The third problem has been the exclusion of prior achievement scores as an independent measure. When a prior ability score is omitted from the list of explanation variables, estimates of the influence of family factors may be biased. To avoid this problem, Hanushek (1972) and Murnane (1975) included pre-test scores as independent variables. The pre-test then accounts for the not directly measured influences on achievement of genetic endowment, family influences, and all of a student's prior school experiences.

There is another rationale for including prior academic achievement as an independent measure. Returning to equation (1), "Y" represents the output, academic achievement. Achievement in equation (1) is not confined to a specific time period. Without specifying the production

time frame, it is difficult to isolate the impact of specific production factors. One way to overcome this time problem is for "Y" to represent gains in achievement.

Gains in achievement can be viewed as value added to the human capital of the individual, as Thomas (1971) has. It is assumed that when the student is in school, he or she will acquire additional knowledge during the schooling process. Value added refers to these gains in additional learning which occur within a specific time period. Assuming that learning takes place when certain units of skills have been mastered, value added is the number of these units acquired at each stage.[3] Using this concept, the "Y" variable becomes "$Y_i^{t+1} - Y_i^t$."

The problem with using a value added output is the measure when mathematically computed is the difference between a student's posttest (the raw score at the end of the year) and pre-test (the raw score at the beginning of the school year); such difference scores have been criticized by Cronbach and Furby (1970) as unsuitable for estimating true gains. In a pre-posttest situation, there is a lapse of time between the first and second test. When examined statistically, this lapse of time sometimes shows that the student who scored high on the pre-test has a lower score on the posttest (the inverse of this is also true). Because standardized tests are not perfectly reliable, contain measurement errors, and have a pre-test correlation of less than one, there <u>appears</u> to be a change in the scores even if no change really has occurred. The difficulty with this phenomenon is, if individuals with scores seemingly containing

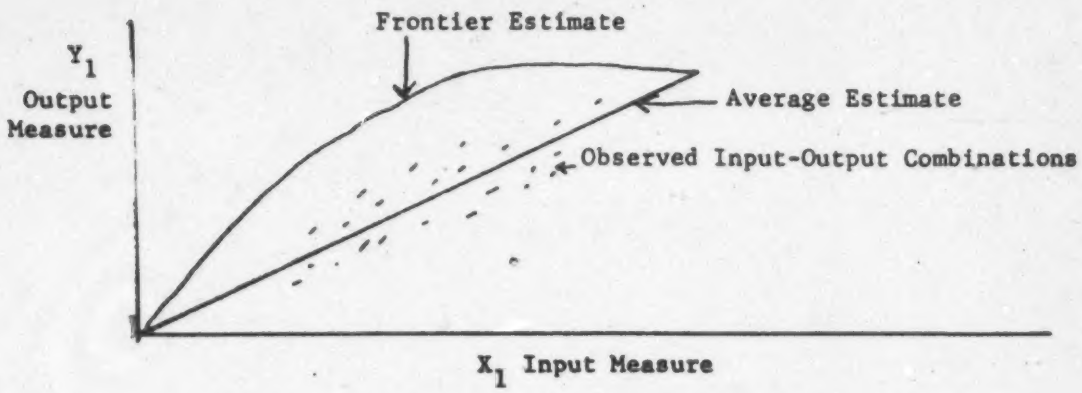
large errors of measurement are included in the analysis, inaccurate estimates of the impact of resources on their scores are more likely. Therefore, one needs to obtain estimates of gains from which any bias due to errors of measurement have been eliminated.

This can be done by subtracting the pre-test from the posttest and regressing the subsequent gain score upon the independent variables, including the pre-test score. This adjusts for some of the problems associated with using difference scores and uses the value-added output.

The final problem deals with relationships between gains in achievement and the series of input measures which are formulated by a linear additive equation. When calculating the linear function, the majority of production functions used the average estimate. It has been argued that the educational production function should be estimated as the outside boundary of the observed combinations referred to as the frontier estimate. Levin (1974). (See Figure 1.)

Insert Figure 1 here

Comparison of Average Estimate and Frontier Estimate



The arguments over whether to use the frontier estimate or average estimate center on: 1) the behavior of the educational producers, 2) stochastic properties of the regression equation, and 3) error of measurement (Lau, 1977). The proponents of the frontier estimate maintain that educational producers fail to make optimum choices among production possibilities. Therefore, they are just as likely to operate at a point within the boundary of the set of production possibilities as at the production frontier. However, although there is no external reward or requirement to optimize resources, it may be that educational producers are as likely to operate close to the production frontier as away from it. Even though schools may not be run as efficiently as possible, it does not seem plausible to maintain that educational producers would operate as inefficiently as possible.

The stochastic argument centers on the equation model. When using the frontier estimate, one assumes that the production function is perfectly deterministic and any deviations of actual observations are caused by inefficiencies. However, these deviations may reflect random fluctuations of individual student test performance. When estimating an educational production function one assumes there will be measurement errors in both the input and output measures. Recognizing that these errors will exist, it is questionable if the observations are in fact totally accurate representations of test performance or family, peer, teacher or school characteristics. For these reasons, the average estimate was used in this study.

The other problem with the linear additive equation concerns the reciprocal effects between output and input measures. There have been several criticisms of the appropriateness of the linear model to reality, when examining the relationship between student achievement and family, teacher, and school characteristics (Levin, 1970; Boardman, Davis and Sanday, 1977). It is doubtful that a linear regression of one dependent variable upon a set of independent variables yields proper estimates, particularly when the value of that variable may be determined simultaneously with other variables on the right side of the equation model.

Method

The design for this study includes two distinctive models. The first model is linear and is specifically designed to represent: 1) the value added concept, 2) a limited number of constructs suspected of influencing achievement based upon previous educational and psychological research; and 3) individual achievement scores. The equation for this model is:

$$Y_i^{+1} - Y_i = \alpha + B_i Y_i + B_1 X_{i1}^{+1} + B_2 X_{i2}^{+1} + B_3 X_{i3}^{+1} + B_x X_{i4}^{+1} + e_i \qquad (2)$$

where Y_i^{+1} = individual post-test performance,

Y_i = individual pre-test performance,

α and $B_i \ldots B_4$ = regression parameters which are unknown,

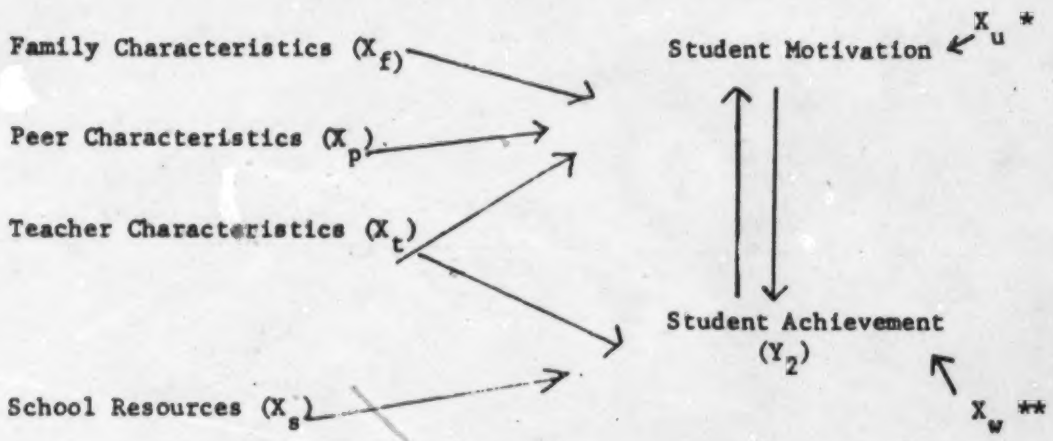
$X_{i1}^{+1} \ldots X_{i4}^{+1}$ = vectors of explanatory variable representing individual student, peer group, teacher and school characteristics measured at the posttest period (which assumes that they were present during pre- and posttest periods).

e_i = residual term.[4]

Recognzing some of the limitations of linear analyses, the second model is designed to examine the reciptrocal function among achievement scores and several factors suspected of influencing student learning. The exogenous variables (i.e., input variables) represent family, peer, teacher and school characteristics, whereas the endogenous variables (i.e., output variables) are motivation and achievement. Specific variables used in the analyses were determined by their beta weights (i.e., significance of their contribution to explaining output variance) found in a prior ordinary least squares analysis. The model constructed for simultaneous equations analyses is:

Insert Figure 2 here

Simultaneous Equations, Model II



* Disturbance terms standing for factors influencing motivation but not explicitly measured.

** Disturbance term standing for factors influencing achievement but not explicitly measured.

(3)

$$Y_1 = P_{1f}X_f + P_{1p}X_p + P_{1t}X_t + P_{13}Y_2 + P_{1u}X_u,$$

and

$$Y_2 = P_{2s}X_s + P_{2t}X_t + P_{21}Y_1 + P_{2w}X_w.$$ [5]

Sample

The sample for this study is particularly unique because all achievement test scores as well as all other information were matched to individual students. Information on family, peer group, teacher and school characteristics were obtained for 493 elementary school children, grades three through seven in four urban schools.[6] Sample selections were based on: 1) student attendance at one school for at least two consecutive years; and 2) the possibility obtaining matched family, peer group and teacher characteristics for that individual. Use of this selection criteria resulted in complete data sets.

School selections were not made on the basis of any geographical or sociological qualifications; rather the schools were selected because they offered the greatest possibilities for obtaining complete information sets on students attending those schools. None of the schools has a racially integrated student body. However, all of the schools do have integrated faculties. All of the schools are within walking distance of the majority of the student population. Three of the four schools have levels from kindergarten through eighth grade. These three schools receive additional seventh grade students from a kindergarten through sixth neighboring school or schools. The fourth school is an experimental school which has grades from kindergarten through sixth.

School assignments to homerooms are based on heterogenous ability groupings whereas classroom placements for reading and mathematics are homogenous. All of the schools participate in departmentalized reading and mathematics programs. Therefore, individual pre- and posttest reading and mathematics achievement scores had to be matched with respective peer group and teacher characteristics.

Peer group skills information (i.e., level and classroom scores of performance in reading and mathematics achievement) was calculated by identifying reading and mathematics peer groups, averaging their performance and matching these scores with individual students. Thus, interpretations of peer group performance is relative to sampled classrooms, not national norms.

Data on schools and student populations were acquired during visits to the schools and surrounding neighborhoods. Information on individual students was obtained from questionnaires and interviews and verified by school records when possible.

Results

Regression analyses on the four achievement tests, vocabulary, reading achievement, mathematics computation, and mathematics problem solving indicated that for each of the tests there are different factors (i.e., student, peer group, school and teacher characteristics) that affect student achievement. Therefore, reading and mathematics achievement tests will be discussed separately.

Insert Table 1

Student factors that were found to affect vocabulary achievement are: pre-test, report card grades in reading and mathematics and age (see Table 2). While one would expect the pre-test to be the dominant determinate of gains in achievement, it is interesting to note the effect of report card grades. High report card grades in reading positively affect vocabulary achievement gains. With respect to age, as the student gets older he/she makes less gains in vocabulary achievement. The age variable similarly affects achievement gains in reading and mathematics concepts.[7]

Teacher factors that affect vocabulary achievement are highest degree and recency of last self-initiated extra curricular student activity.

Insert Table 2

The results for reading achievement are similar to the results for vocabulary (see Table 3). Student factors that affect reading achievement are the pre-test score and age. The peer group factor that affects reading achievement is peer group performance in reading. Teacher factors that affect reading achievement are: 1) highest degree, 2) recency of last voluntary professional experience, and 3) recency of last self-initiated student extra curricular student activity. The students with teachers having only baccalaureate degrees had higher achievement gains. The more recent the voluntary professional experience, the smaller the effect on reading achievement.

Insert Table 3

The results of the mathematics tests are more encouraging than the reading tests with respect to school factors. As noted in reading achievement results, student factors that affect mathematics problem solving achievement are previous achievement and report card grades (see Table 4). However, the results pertaining to the school factors are considerably different. Students who attend School 2 are more likely to have less gains in mathematics problem solving achievement that if they attended Schools 1, 3, or 4. Furthermore, the more time allowed for basic skill instruction daily, the better the achievement gains for mathematics problem solving. Again, we find that teachers with additional credit hours beyond the baccalaureate degree have less of an effect on student achievement than teachers with bachelor's degrees and bachelor's degrees plus 20 hours.

Insert Table 4

In the mathematics concept achievement test a different variable appears to be significant relative to the student factors (see Table 5). Boys have higher gains in mathematics concept achievement than girls. The sex differential also occurs with respect to the teacher factors. Students with male teachers have higher gains in mathematics concept achievement.

Results of the Simultaneous Equations

The overall results of the simultaneous equations showed: 1) there appears to be an interdependent relationship between academic achievement and motivation (motivation was measured by a teacher-awarded score indi-

cating effort); and 2) some of the factors that are significant in the regression analyses are significant in the simultaneous equations model. Methodologically, the standard errors of the regression coefficients seem to be better estimators than the standard errors of the beta coefficients in the regression analyses. These results can be found by examining the differences between the standard errors of the beta coefficients in Tables 2, 3, 4, and 5 and the standard errors of the regression coefficients in Tables 6, 7, 8, and 9. One should be cautioned, however, that the equations are not similar and a direct comparison would be misleading. The results of these findings are reported in Tables 6, 7, 8, and 9.

Insert Table 5

For the equations examining vocabulary achievement (table 6) when the dependent measure is vocabulary achievement, the pre-test, teacher degree and peer group reading performance are significant, which they were in the regression analyses. When the dependent measure is effort, the standardized gain score in vocabulary achievement, pre-test and grades are significant. The relationship of the effort score, grades and achievement test suggests that teacher perceptions of student performance influence attitude and academic performance in school. This hypothesis is supported by the results from the other simultaneous equations.

Insert Table 6

For the equations examining reading achievement (Table 7) when the dependent measure is reading achievement, effort, School 2 and 3, teacher degree, and time allocated for basic skill instruction daily are significant. When the dependent measure is effort, the standardized gain score in reading achievement, teacher degree and School 2 and 3 are significant. The significance of the effort score in equation 1 and the significance of the standardized gain score in reading achievement in equation 2 suggests the interdependent relationship of these two variables. The emergence of the significance of schools in both equations seems to indicate that something is going on in schools which influences motivation and achievement.

Insert Table 7

For the equations examining mathematics concept achievement (Table 8) when the dependent measure in mathematics concept achievement, effort, School 2, peer group performance in mathematics problem solving and time allocated for basic skill instruction daily are significant. When effort is the dependent variable, standardized gain score in mathematics concept achievement, School 3 and teacher degree are significant. The continued significance of the time variable supports the importance of the relationship between instructional time and achievement. As for the equations examining reading achievement, the significance of the standardized gain score in equation 2, the significance of the effort score in equation 1 supports the hypothesis of an interdependent relationship between these

two variables.

Insert Table 8

For the equations examining mathematics problem solving (Table 9), when the dependent measure is mathematics problem solving achievement effort, School 2, peer group performance in mathematics concept achievement, teacher degree and time allocated for basic skill instruction daily are significant. When the dependent measure is effort, standardized gain score in mathematics problem solving achievement and teacher degree are significant. These results seem to reinforce the regression findings and the hypothesis concerning the interdependent relationship between achievement and motivation. The results of the simultaneous equations models validate the findings of the regression analyses and theoretical discussion of this study.

Discussion

The overall findings indicate that when the individual student is the unit of analysis, student, peer group, teacher, and school characteristics are related to academic achievement. The inconsistency of these results with other findings (Colemen, et al, 1966) can probably be attributed to the improved measures used in this study. When Hanushek (1972), Murnane (1975), and Summers and Wolfe (1977) used the individual student as the unit of analysis, similar factors (peer groups and teacher characteristics) were also found to be related to achievement. Therefore, it seems when the dependent measure is not aggregated, analysis is more likely to detect

factors in the learning environment which affect academic achievement.

In examining the results, interpretations must be made recognizing errors in and lack of refinement of the measures. Values of the adjusted R^2 and the significance of the beta weights in all the models for at least two factors show that the factors chosen for this investigation were appropriate.

The results of the student factors indicate the consistent importance of the pre-test, which seems to imply the necessity for identifying present school academic skills and their subsequent effect on later academic performance when constructing a model. The results of the variable of age could be explained by two elements, student efficacy and student learning development.

Relating to efficacy, as the student remains in school and continues to make insignificant gains in achievement, his/her power to change these results probably decreases. This is validated further by the results for the variables effort and Report Card Grades. Students with high effort scores and high Report Card Grades have higher gains in reading and mathematics achievement. Both effort scores and report card grades are teacher-awarded scores. Because they are teacher-awarded, they can be assumed to represent teacher perceptions of student performance. Students with low gain scores in achievement, low effort and report card grades are more likely to feel helpless to change these results (Weiner, 1979). As the student grows older, these feelings of helplessness probably increase and are continually reinforced by low academic achievement test score

results and report card grades.

It may be that in elementary school the academic achievement of children begins to level off by the upper elementary grades. Academic achievement may reach a point of diminishing marginal productivity by the upper grades. No matter how many additional resources are allocated to the student (e.g., instructional time, materials, etc.), there are less and less additional gains in achievement. Hence for older children, not only are their gains in achievement smaller, but the effects of resources allocated to increase academic performance would tend to be insignificant.

The relationship between student learning development and the negative effect of age may be the result of what is being measured and the addition of new academic skills. The academic skills that can be isolated and measured from first to third grade are easier to determine (progression from inability to add to the ability to add three place numbers) than academic skills mastered from fifth to seventh grade. It appears that for each progressive grade the number of skills decreases, although the complexity which is probably more difficult to measure increases.

Other student factors that affect academic achievement are: 1) sex of the student and teacher (i.e., boys had higher gain scores in mathematics achievement than girls) and men are found to be more effective mathematics teachers than women; and 2) employment of the mother and father (i.e., if the mother and father are both employed, students are more likely to have low or average gains in achievement). Results of other studies

(Hilton and Berglund, 1974; and Reeves, 1973) also revealed that boys have higher mathematics achievement scores than girls. Aiken (1976) and Fennema and Sherman (1977) maintain that these patterns are probably the result of socio-cultural factors. If mathematics achievement is affected by sex stereotyping, future studies should determine what in the schooling environment (e.g., instructional materials, peer group and teacher perception, etc.) either positively or negatively affects mathematics achievement for males or females. However, in this study, mathematics achievement of males and females is neither school nor family related. It may be that sex stereotyping relative to mathematics achievement is pervasive.

Results relating to employment show that if the mother and father are both employed, students are more likely to have low or average gains in achievement. Studies examining the relationship between working parents and student achievement found that full or part-time work by mothers did not negatively impact on student verbal achievement (Leibowitz, 1972). The inconsistency of these results with the findings of this study may be related to the sample populations (Leibowitz used 805 three to five year olds). Leibowitz (1977) found that it is not just the time but specific uses of time and labor-saving capital goods in the home that affect a child's verbal ability. This implies that perhaps the quality of time working parents spend with older children may be more directly related to school academic achievement.

It seems that further study should be undertaken to determine the

relationship between the kinds of activities working parents engage in with their children and the child's academic achievement. This is particularly important considering the increasing number of 6 to 17 year olds with working mothers (The Condition of Education, 1978). There may be specific activities (e.g., visits to museums, helping with homework, etc.) that working parents can do with their children to increase their effectiveness as learners.

Peer group performance affects reading and mathematics achievement. Low achievers and average achievers do better with higher achieving peer groups. These results suggest, contrary to the Coleman study (1966) that when race and socio-economic factors or the peer group are held constant, ability levels of the peer group are related to academic achievement. Something is probably occurring within the learning environment (e.g., peer group interaction, assigned peer group learning tasks, expectations of teachers and students, etc.) that enhances student productivity. These results demonstrate the need for classroom observations of student learning.

The results of the teacher factors reveal that teachers with bachelor's degrees are more effective in raising student academic achievement than teachers with master's degrees. Similar negative effects were found relating to experience. It may be that recency of their baccalaureate and great motivation to teaching have a positive effect on student performance. After several years, by contrast, the enthusiasm of older teachers may be lost and not rekindled by other professional expereinces. For example,

student achievement scores were not positively affected by the recency of their teacher's last voluntary professional experience (e.g., workshops, seminars, etc).

These results pertaining to degree and experience have some implications for allocating resources. Over 80 percent of most school budgets are allocated for salaries. Increments in teacher salary are often made on these bases of experience and earned graduate hours. It seems there is an inefficient allocation of resources to continue to pay teachers for characteristics that do not seem to affect student performance. The results of this study relating to degree and years of experience raise some serious questions regarding the criteria used to allocate resources for teacher salaries.

Results for the time variables (i.e., time allocated for basic skill instruction daily, and student attendance) were different. However, when Wiley (1975) used attendance as a product of days present and hours of instruction, findings were similar to the results of this study for the variable time allocated for basic skill instruction. If the time factor and student attendance were logged, the results may have been even stronger in regard to time. Moreover, if these time factors were further refined to represent student engaged learning time, and teacher instruction time, the school effects may have been greater. Examining how these factors affect achievement can probably be more accurately measured by observations in classrooms, as currently being studied by Thomas (1977).

Results from the simultaneous equations show the importance of schools

to academic achievement. This research supports the findings of Klitgaard and Hall (1975) that there are schools that consistently produce outstanding students (even after socio-economic factors are controlled). In this study two schools appeared to be more effective. The least effective school had: 1) nearly a third more students than the other schools, 2) a higher number of students per teacher, and 3) the lowest amount of pupil staffing costs. These findings and the teacher, time, and pre-test results suggest that if individual students are the unit of analysis in educational production functions, school resources are revealed to be related to gains in academic achievement.

Summary

Interpretations of these findings should be made recognizing some of the limiting conditions surrounding the design of the study. If additional students from more diverse socio-economic and racial backgrounds were studied, the sample would have more accurately represented the population in urban schools. Another variance problem concerns the number of schools. If the number of schools had been greater, it would have strengthened the findings related to school effects. As for the instrument measuring achievement, another instrument for identifying what specific learning tasks have been mastered would probably have contained fewer measurement errors. Results of the simultaneous equations suggest that further work should be undertaken on estimating models that examine interdependent relationships among the dependent and interdependent measures.

Relating to the independent variables, additional information concerning the student learning environment (e.g., student engaged learning time, qualified learning tasks, etc.) may have reinforced school effects findings. In addition to using questionnaires and interviews to find how much time teachers spend on instruction, classroom observations would probably reveal more information on the quality of time teachers spend on instruction. Furthermore, there may be other resources outside of school that explain the relationship between school effects and achievement. Garner (1978) found variations in the amount of time students were assigned for homework activities. These variations were strongly related to teacher reports of class average ability levels. Lower ability students received less total exposure to school learning activities than did average students; and both lower and average ability level classes receive less than higher ability classes. Homework time spent by students may be another resource that reflects both school and family factors. If one is to measure the relationship of school effects and achievement, the quality and quantity of activities that students engage in both in and outside of school should be examined.

Table 1

Regression Results for Vocabulary Achievement

Dependent Variable: Standardized Gain Score in Vocabulary Achievement	
Independent Variables	Beta
1. Grade	.09[a]
2. No. of Days Present	- .01
3. Sec Student	.08
4. Pretest Vocabulary	- .46**
5. Teacher Highest Degree Masters + 20 hrs.	- .37**
6. Mother + Father Employed	.11
7. Family Size	- .01
8. Recency Last Voluntary Professional Experience	- .02
9. Per Pupil Staffing Costs	.01
10. Report Card Grade Effort	- .08
11. Sex Teacher	- .11
12. Report Card Grade Reading Level	.16*
13. Report Card Grade Reading	.08*
14. Socioeconomic Status	.09
15. Recency Last Self-initiated Extra Curricular Student Activity	.03
16. Pupil Teacher Ratio	- .04
17. Race Teacher	- .08

18.	Report Card Grade Math Level	- .17**
19.	Report Card Grade Math	.01
20.	Teacher Years of Experience	.01
21.	Teacher Highest Degree Bachelors + 20 hrs.	- .27*
22.	School 2	- .45
23.	Report Card Grades	- .05
24.	Age	- .11**
25.	Peer Group Mathematics Concept Achievement	.04**
26.	Teacher Highest Degree Masters	- .36*
27.	Teacher Years of Experience at School	- .01
28.	School 1	- .32
29.	Time Allocated for Basic Skill Instruction Daily	.02
30.	Peer Group Reading Achievement	.09
31.	School 3	- .67
32.	Constant	1.68
	Multiple R .55**	

Note. N = 493

[a]All numbers rounded to nearest hundredth

*p $\leq$ .05

**p $\leq$ .01

Table 2

Regression Results for Reading Achievement

Dependent Variable

Standardized Gain Score in Reading Achievement

Independent Variables	Beta
1. Grade	- .02[a]
2. No. of Days Present	.02
3. Pretest Reading	- .46**
4. Sex Student	.08
5. Teacher Highest Degree Masters + 20 hrs.	- .29*
6. Mother + Father Employed	.08
7. Family Size	- .02
8. Per Pupil Staffing Costs	- .03
9. Recency Last Self-initated Extra Curricular Student Activity	.05**
10. Report Card Grade Effort	- .02
11. Recency Last Voluntary Professional Experience	- .06
12. Socioeconomic Status	- .08
13. Report Card Grade Reading Level	.09
14. Sex Teacher	- .05
15. Report Card Grade Reading	.07
16. Pupil Teacher Ratio	- .04
17. Race Teacher	- .09

18.	Report Card Grade Math Level	- .11
19.	Report Card Grade Math	.02
20.	Teacher Years of Experience	.01
21.	Teacher Highest Degree	- .21
	Bachelors + 20 hrs.	
22.	School 2	.23
23.	Report Card Grades	.10
24.	Age	- .08**
25.	Peer Group Mathematics	.05
	Concept Achievement	
26.	Teacher Highest Degree Masters	- .25
27.	Teacher Years of Experience at School	.05
28.	Time Allocated for Basic Skill	.01
	Instruction Daily	
29.	Peer Group Reading Achievement	.02*
30.	School 1	.81
31.	School 3	.68
32.	Constant	3.71
	Multiple R .63**	

Note. N = 493

[a]All numbers rounded to nearest hundredth

*$p \leq .05$

**$p \leq .01$

Table 3

Regression Results for Mathematics Problem Solving

Dependent Variable

Standardized Gain Score in Mathematics Problem Solving Achievement

Independent Variables	Beta
1. Grade	.09[a]
2. No. of Days Present	- .03
3. Sex Student	.09
4. Report Card Grade Reading Level	.07
5. Mother + Father Employed	- .07
6. Recency Last Voluntary Professional Experience	.04
7. Family Size	.03
8. Per Pupil Staffing Costs	.07
9. Report Card Grade Reading	.11**
10. Teacher Highest Degree Masters	- .42*
11. Socioeconomic Status	.04
12. Recency Last Self-initiated Extra Curricular Student Activity	- .01
13. Report Card Grade Effort	.02
14. Teacher Highest Degree Bachelors + 20 hrs.	- .20
15. Pretest Mathematics Problem Solving	- .56**
16. Pupil Teacher Ratio	- .02
17. Sex Teacher	- .05

18.	Race Teacher	- .08
19.	Report Card Grade Math Level	.05
20.	Report Card Grade Math	.12**
21.	Teacher Years of Experience	.02
22.	School 2	-1.56*
23.	Report Card Grades	.07
24.	Age	- .04
25.	Peer Group Mathematics Concept Achievement	- .01
26.	Teacher Years of Experience at School	- .01
27.	Teacher Highest Degree Masters + 20 hrs.	- .32*
28.	School 1	-1.48
29.	Time Allocated for Basic Skill Instruction Daily	.09**
30.	Peer Group Reading Achievement	.02*
31.	School 3	-1.77
32.	Constant	-8.49

Multiple R .63**

Note. N = 493

[a]All numbers rounded to nearest hundredth

*$p \leq .05$

**$p \leq .01$

Table 4

Regression Results for Mathematics Concept Achievement

Dependent Variable

Standardized Gain Score in Mathematics Concept Achievement

Independent Variables	Beta
1. Grade	.03[a]
2. No. of Days Present	.02
3. Sex Student	.13**
4. Pretest Mathematics Concept	- .58**
5. Teacher Highest Degree Masters + 20 hrs..	- .15
6. Mother + Father Employed	- .07
7. Family Size	.02
8. Per Pupil Staffing Costs	.05
9. Recency Last Self-initiated Extra Curricular Student Activity	- .06**
10. Report Card Grade Effort	.03
11. Recency Last Voluntary Professional Experience	.02
12. Report Card Grade Reading Level	.05
13. Sex Teacher	- .17
14. Socioeconomic Status	.03
15. Report Card Grade Reading	.03
16. Pupil Teacher Ratio	.05*
17. Race Teacher	- .04

18.	Report Card Grade Math Level	.04
19.	Report Card Grade Math	.08
20.	Teacher Years of Experience	.01
21.	Teacher Highest Degree Bachelors + 20 hrs.	- .15
22.	School 2	- .63
23.	Report Card Grades	.17**
24.	Age	- .08**
25.	Peer Group Mathematics Concept Achievement	.03**
26.	Teacher Highest Degree Masters	- .23
27.	Teacher Years of Experience at School	- .01
28.	School 1	- .84
29.	Time Allocated for Basic Skill Instruction Daily	.04
30.	Peer Group Reading Achievement	.01*
31.	School 3	-1.07
32.	Constant	-4.46

Multiple R .63**

Note. N = 493

[a]All numbers rounded to nearest hundredth

*$p \leq .05$

**$p \leq .01$

Table 5

Simultaneous Equations Results for Vocabulary Achievement

Equation 1

Endogenous Variable

Standardized Gain Score in Vocabulary Achievement

Exogenous Variable	Structural Form	t Value
1. Report Card Grade Effort	- .04[a]	- .64
2. School 1	- .04	- .46
3. School 2	- .11	- .79
4. School 3	- .16	1.16
5. Peer Group Reading Achievement	.02	4.25*
6. Teacher Highest Degree Bachelors + 20 hrs.	- .02	- .17
7. Teacher Highest Degree Masters	- .26	-2.47*
8. Teacher Highest Degree Masters + 20 hrs.	- .30	-3.09*
9. Pretest Vocabulary Achievement	- .33	-9.78*
10. Time Allocated for Basic Skill Instruction Daily	- .02	1.47

[a]All numbers rounded to nearest hundredth

*Significant at the $p \leq .05$

Table 5

Simultaneous Equations Results for Vocabulary Achievement

Equation 2

Endogenous Variable

Report Card Effort

Exogenous Variable	Structural Form	t Value
1. Standardized Gain Score in Vocabulary Achievement	- 3.04[a]	2.21*
2. School 1	.20	.68
3. School 2	- .09	.29
4. School 3	- .27	.52
5. Peer Group Reading Achievement	.05	1.61
6. Teacher Highest Degree Bachelors + 20 hrs.	.34	.92
7. Teacher Highest Degree Masters	- .78	- 1.31
8. Teacher Highest Degree Masters + 20 hrs.	- .62	- .94
9. Pretest Vocabulary Achievement	- 1.01	- 2.21*
10. Report Card Grades	.57	3.37*
11. Teacher Years of Experience	- .01	- .70

[a]All numbers rounded to nearest hundredth

*Significant at the p .05

Table 6

Simultaneous Equations Results for Reading Achievement

Equation 1

Endogenous Variable

Standardized Gain Score in Reading Achievement

Exogenous Variable	Structural Form	t Value
1. Report Card Grade Effort	.16[a]	2.47*
2. School 1	-.09	-1.08
3. School 2	.67	4.78*
4. School 3	.38	3.07*
5. Peer Group Vocabulary Achievement	.07	1.36
6. Teacher Highest Degree Bachelors + 20 hrs.	-.09	- .95
7. Teacher Highest Degree	-.23	- .02
8. Teacher Highest Degree Masters + 20 hrs.	-.22	-2.49*
9. Pretest Reading Achievement	-.37	-1.15
10. Time Allocated for Basic Skill Instruction Daily	-.04	-3.58*

[a]All numbers rounded to nearest hundredth

*Significant at the $p \leq .05$

Table 6

Simultaneous Equations Results for Reading Achievement

Equation 2

Endogenous Variable

Report Card Grade Effort

Exogenous Variable	Structural Form	t Value
1. Standardized Gain Score in Reading Achievement	- 1.93[a]	- 3.16*
2. School 1	- .01	- .06
3. School 2	.62*	2.21*
4. School 3	1.00*	2.83*
5. Peer Group Vocabulary Achievement	.05	.38
6. Teacher Highest Degree Bachelors + 20 hrs.	.04	1.88
7. Teacher Highest Degree Masters	.45	- 1.41
8. Teacher Highest Degree Masters + 20 hrs.	.03	- .12
9. Pretest Reading Achievement	.69	- 3.16*
10. Report Card Grades	.84	1.15
11. Teacher Years of Experience	- .01	- 1.63

[a]All numbers rounded to nearest hundredth

*Significant at the $p \leq .05$

Table 7

Simultaneous Equations Results for Mathematics Concept Achievement

Equation 1

Endogenous Variable

Standardized Gain Score in Mathematics Concept Achievement

Exogenous Variable	Structural Form	t Value
1. Report Card Grade Effort	.26[a]	3.83*
2. School 1	- .17	- 1.92
3. School 2	.71	4.80*
4. School 3	.14	1.25
5. Peer Group Mathematics Problem Solving	.03	4.99*
6. Teacher Highest Degree Bachelors + 20 hrs.	- .11	- 1.16
7. Teacher Highest Degree Masters	- .14	- 1.27
8. Teacher Highest Degree Masters + 20 hrs.	- .18	- 1.85
9. Pretest Mathematics Concepts	- .46	- 1.27
10. Time Allocated for Basic Skill Instruction Daily	- .08	- 5.52*

[a]All numbers rounded to nearest hundredth

*Significant at the $p \leq .05$

Table 7

Simultaneous Equations Results for Mathematics Concept Achievement

Equation 2

Exogenous Variable

Report Card Grade Effort

Endogenous Variable	Structural Form	t Value
1. Standardized Gain Score in Mathematics Concept Achievement	1.09[a]	- 3.82*
2. School 1	- .07	- .47
3. School 2	.11	.77
4. School 3	.45	2.49*
5. Peer Group Mathematics Problem Solving	.02	1.50
6. Teacher Highest Degree Bachelors + 20 hrs.	.45	2.74*
7. Teacher Highest Degree Masters	- .14	- .73
8. Teacher Highest Degree Masters + 20 hrs.	.21	1.17
9. Pretest Mathematics Concepts	- .50	- 4.00*
10. Report Card Grades	.84	1.59
11. Teacher Years of Experience	- .01	- 1.90

[a]All numbers rounded to nearest hundredth

*Significant at the $p \leq .05$

Table 8

Simultaneous Equations Results for Mathematics Problem Solving Achievement

Equation 1

Endogenous Variable

Standardized Gain Score in Mathematics Problem Solving Achievement

Exogenous Variable	Structural Form	t Value
1. Report Card Grade Effort	.28[a]	4.01*
2. School 1	- .07	- .77
3. School 2	.46	2.96*
4. School 3	- .05	- .33
5. Peer Group Mathematics Concept Achievement	.02	4.07*
6. Teacher Highest Degree Bachelors + 20 hrs.	- .19	- 1.72
7. Teacher Highest Degree Masters	- .34	2.97*
8. Teacher Highest Degree Masters + 20 hrs.	- .32	- 3.06*
9. Pretest Mathematics Problem Solving	- .44	- 1.23
10. Time Allocated for Basic Skill	- .07	- 4.49*

[a]All numbers rounded to nearest hundredth

*Significant at the $p \leq .05$

Table 8

Simultaneous Equations Results for Mathematics Problem Solving Achievement

Equation 2

Exogenous Variable

Report Card Grade Effort

Endogenous Variable	Structural Form	t Value
1. Standardized Gain Score in Mathematics Problem Solving	- 1.30[a]	- 3.09*
2. School 1	.02	.14
3. School 2	- .03	1.50
4. School 3	.35	1.36
5. Peer Group Mathematics Concept Achievement	.02	1.64
6. Teacher Highest Degree Bachelors + 20 hrs.	.35	- 1.55
7. Teacher Highest Degree Masters	- .46	3.85*
8. Teacher Highest Degree Masters + 20 hrs.	.01	- 3.42*
9. Pretest Mathematics Problem Solving	- .65	- 3.42*
10. Report Card Grades	.91	- 1.41
11. Teacher Years of Experience	- .01	- 1.87

[a]All numbers rounded to nearest hundredth

*ASignificant at the p .05

Footnotes

[1]There are several problems in specifying a production function model with many variables. One problem involves the "r-value" which measures the association between the output and input variables. If numerous variables are specified in the model, the "r-value" many be overestimated. In relation to the beta weights, if many variables representing the same factor are included in the model, it tends to increase the likelihood of multicolinearity. For example, if several variables represent one factor such as socio-economic status, the coefficients of the variables may be underestimated because they are partially represented in other variables and therefore share a common variance. The production function model would probably be more conservatively estimated by identifying fewer variables thereby lessening the possibilities of multicolinearity and over-fitted regression equations.

[2]Hanushek (1972) found when using individual scores from 2,445 third grade students that the teacher characteristics that appear to be important are not the characteristics purchased by schools. For both second and third grade teachers, the score on a verbal facility test and recency of their last educational experience had the greatest effect on student achievement gains. Different teachers and different classroom compositions, however, did not affect the achievement of Mexican-American students. Yet, differences in teachers and classrooms did make a difference to achievement gains of white students regardless of their socio-economic level. When using individual output and input scores, Murnane (1975) found different

gains in academic achievement among different classrooms. These differences consist of differences among classrooms within the same school and differences among schools. Differences in the quality of classroom environments had a greater effect on children's math achievement than on their reading achievement.

[3]In this instance, value added does not refer to monetary gain in potential or expected income.

[4]This method controls for errors of measurement, regression toward the mean and problems of correlation between pre- and post test. Another alternative to adjusting for measurement errors is the covarite method.

$$Y_i^{+1} = B_i Y_i + B_1 X_{i1}^{+1} + B_2 X_{i2}^{+1} + B_3 X_{i3}^{+1} + B_4 X_{i4}^{+1} + e_i \qquad (3)$$

where Y_i^{+1} = individual posttest performance,

Y_i = individual pre-test performance,

and $B_i \ldots B_4$ = regression paramaters which are unknown,

$X_{i1}^{+1} \ldots X_{i4}^{+1}$ = vectors of explanatory variables representing individual student, peer group, teacher and school characteristics,

e_i = residual term

The problem with the covariate method is it does not reflect the "value added concept." Secondly, in Equation (2) part of the correlation between the pre- and posttest scores is subtracted out of the dependent

variable. Since this is not being done in the covariate method, the R square, adjusted R square, and overall F's are higher. Thus Equation (2) is a more conservative estimate.

[5]Several statistical methods are used to estimate the structural simultaneous equation models. The most frequently used methods are two-stage least squares (2SLS) and three-stage least squares (3SLS). The problem with 2SLS is that the formula for estimating the parameters of the equations does not take into account the correlation of the disturbances across equations. If the disturbances of the different structural equations are not examined, information about each equation is incomplete. Therefore, the equation models are not asymptotically efficient. This problem can be avoided by estimating all equations in a simultaneous model by the 3SLS method. The 3SLS method was selected in preference to the 2SLS in order to achieve greater estimator efficiency.

[6]One of the limitations of this study is that only four schools were examined. With only four schools, if size were represented by continuous variables, the variance attributed to school size would be so small that its presence would probably be better explained by the nominal variable, school. Thus school size was eliminated from the analysis.

[7]The achievement scores were obtained from the Iowa Test of Basic Skills, levels 6 through 14. All test scores were expressed as raw scores and subsequently standardized for the analysis. On all the tests, separate regressions were run on high, average, and low gainers.

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